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Will Plants Have a Role in Bioremediation?

Heavy Metals: Accumulators, Tolerance and Exclusion Mechanisms

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Plant Assisted Decontamination

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Plant Assisted Degradation of Organics

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Ecological Considerations of Plant-Based Remediation

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Degradation of Munitions and Chlorinated Solvents by Aquatic Plants

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Nitroreductase and dehalogenase enzymes have been isolated from sediments and soils. Using enzyme linked immunospecific assays (ELISA), a number of aquatic plants have been identified as sources of the enzymes. The plants were then brought back into the laboratory and evaluated as candidates for further remediation studies.

In the case of the nitroreductase, detailed studies with Parrot Feather, Stonewort, Hornwort and Spyrigia in water and sediment systems have shown that the plants readily degrade munitions. Significant findings are:

(1) The pathway for TNT degradation with a plant nitroreductase enzyme has been described. (2) A variety of aquatic and terrestrial plants containing the nitroreductase enzyme have been shown to degrade TNT. (3) RDX and HMX also undergo degradation. (4) Other nitroaromatic compounds associated with TNT manufacturing are also degraded by the plant enzyme system. (5) Monoaminodinitro, diaminomononitro substituted toluenes and benzenes are readily degraded by the enzyme system. (6) No amino coupling products have been detected in any of the systems studied to date, i.e., azo or azoxy compounds. (7) The kinetics of the degradation in water are very fast with disappearance half-lives on the order of minutes for TNT. (8) Mass balances and reaction pathways have been described and the "final fate" of ^{14}C ring labeled TNT has been described. (9) ^{14}C labeled ring opened products are incorporated in the plant material. (10) Aquatic plants with high nitroreductase and laccase activity have been shown to grow well in soil/water systems using soils with high concentrations of TNT (5000 ppm in the soil). (11) The nitro reductase enzyme system is stable in sediments for months in both oxic and anoxic sediments. The enzyme can be isolated from sediments with high organic carbon

with the sediments having the highest organic carbon having the highest enzyme activity. (12) After equilibration of soil contaminated TNT with water and plants no TNT or related compounds could be detected in the aqueous phase even after 8 weeks. (13) The plants are effective in degrading TNT, RDX and HMX in water to below 1 ppb. (14) Using an ELISA field test, indigenous plants at a given site can be identified that degrade TNT.

Based on scaled up bench-top results, the process has been further studied in the field in scaled up batch systems. The results have been consistent with the laboratory findings. In the field study, using TNT contaminated sediment/water/Parrot Feather systems, it was possible to drive the aqueous phase TNT and the transient amino intermediates to below 0.1 ppm (the limit of detection in these studies). In separate studies, parrot feather was shown to reduce TNT and the corresponding intermediates to concentrations below 1 ppb.

Similarly for the dehalogenase enzyme, laboratory studies with Spyrigia and Parrot Feather have shown that the plants can degrade a number of chlorinated aliphatic compounds including the chlorinated solvents TCE and PCE. The pathways, mass balances and kinetics of the reactions have been elucidated.